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PNEUMONYSSUS FOXI, NOV. SP.

AN ARACHNOID PARASITIC IN THE LUNG OF A MONKEY (MACACUS RHESUS)

FRED D. WEIDMAN

On March 7, 1914, an adult male *Macacus rhesus* died in the Philadelphia Zoological Gardens with a subacute catarrhal colitis. Its lungs contained, in addition, sixteen to twenty small lesions about equally divided between the two organs. They were nodular, 2 to 5 mm. in diameter, were situated immediately under the pleura and slightly elevated above the same. The smaller ones were firm throughout, the larger ones with softer umbilicated centers and indurated edges. In some of the lesions smaller hard points were to be made out, suggesting a conglomerate lesion. When fresh they were pink or gray and upon incision found to contain granular gray material with granular gray walls. Upon scraping out the centers of the lesions and examining the contents, the parasitic character of the lesions was at once determined.

Microscopically, the sections of the lesions exhibit sections of an arthropod, lying in granular necrotic material, together with brownish black, extremely finely granular detritus (excrement). Around this there is a slight round-cell infiltrate, very poor in leukocytes and in close relation to a bronchus. A thick fibrous wall of very young type surrounds the whole.

The material used in making the following description was obtained by gently scraping out the interiors of two of the pulmonary lesions. This yielded, from one sac, eleven females and one male; from the other, five females. Free larvae or ova were not found. The parasites had been fixed in situ by formaldehyd 4 per cent., followed by washing in water and hardening in alcohol. Some specimens were teased, the remainder preserved entire and examined first in a watery medium, followed by clearing in glycerin-alcohol mixture, or Farrant's medium. During these studies it was found that the delicate membranes of the caroncle could only be satisfactorily examined *prior* to prolonged immersion in glycerin or Farrant's medium, both of which had a marked tendency to produce shrinkage of the same. Finer structures, such as hairs and plates, were only successfully determined after clearing for several days and examination with the oil immersion lens. All of the specimens proved to be clearly of the same species. None were observed living, the material having been submitted subsequent to fixation.

Grossly, they were barely visible as minute, ovoid, glistening, opaque, white or faintly yellowish bodies.

THE FEMALE

Average females, unruptured and not much distorted or flattened by pressure measure as follows:—

Pubescent female	0.850 × 0.450 mm.
Ovigerous female	0.960 × 0.560 mm.
	0.940 × 0.500 mm.
	0.750 × 0.400 mm.

This gives an average of 0.875 × 0.478 mm. They are ovoid, the body not divided or constricted, the greatest width lying immediately behind the last pair of legs. In none of the specimens, and this also applies to the male, can the outline or even site of internal organs be made out. At most the ovum is discoverable, with occasionally the outlines of a folded embryo, in a ruptured specimen.

In one of the teased specimens dorsal and ventral plates of muscle can be made out. Each lies median, between the two middle pairs of legs. The ventral is much the heavier. It sends many fasciculi laterally to the coxae, a few radiate anteriorly to the capitulum and several posteriorly to the ends of a long, special muscle band extending transversely between the last pair of coxae. Fasciculi also radiate from the dorsal plate, a few anteriorly and many laterally to the coxae. There are other bands extending circumferentially around the posterior body half, but the condition of the specimen illustrating the muscular arrangement does not permit exact description here.

The head is continuous with the body both dorsally and ventrally. There are no eyes. The rostrum projects slightly beyond the general body contour, is triangular, the apex rounded, the lateral edges curled dorsally, but curving quickly ventrally again at the apex. In this way a short, broad longitudinal groove is produced over the dorsum of the rostrum. The hypostome is quadrilateral, save for a slight median anterior marginal peak, a little longer than broad and does not project beyond the rostrum. Its surface is finely pebbled like morocco leather. A shallow longitudinal median furrow extends through almost its whole length, stopping just short of the anterior margin. In the depths of this groove 8 to 13 short blunt teeth are noted, set in oblique manner with their points directed anteriorly and ventrally. On either side of the furrow transverse or slightly oblique muscle bundles are seen under the cuticle, which appear to pass anteriorly and median to the bases of the teeth. Midway between the furrow and the lateral hypostomal border, and well short of the anterior margin of the hypostome, a hair is seen on each side. In addition two small papillae are present on each side of the furrow on the anterior margin of the hypostome.

The mouth parts are markedly retracted, barely projecting beyond the hypostome and not at all beyond the rostrum. The palpi lie dorsal and lateral to the mandibles. They consist apparently of three segments, of which the terminal is best seen, subspherical and capped by a stout, moderately long hair. The mandibles are chelate, lie within a sheath in which they are so far retracted as to be generally invisible. At times the two pointed, untoothed fingers of each, one shorter than the other, may barely extend beyond the mouth parts.

There are four pairs of legs, the first two geniculate. The first pair is close to, and its proximal segment (coxa) fused with, the capitulum. The second pair is close to the first pair, with no intercoxal space. The third pair is but a short distance, perhaps the width of a coxa, behind the second, and the fourth pair is at a similar distance from the third. There is no special interval separating the first and last two pairs of legs. The first three legs are subequal in length (0.22 mm.), the last one a little longer (0.25 mm.).* No legs are as long as the body width. Each leg has six articles, although at first glance they may appear to have seven or eight. This is due to the presence of the "fehlenden" muscular insertion of Winkler, which produces a ring simulating the division line between two segments. This ring appears constantly in the tarsus, is well marked constantly in the femora of the two middle pairs of legs and more faintly and only fairly constantly in the femora of the first and fourth pairs of legs. The tibia and patella are of about the same size, much shorter and heavier than the tarsus. The femur is at least twice as long as broad. The trochanter and coxa are much heavier than any of the other segments and irregularly pyramidal in form. The coxa is fully twice as broad as long, its posterior wall long, its anterior shortened by half in the last pair of legs and almost to nil in the three anterior pairs. Its ventral surface bears, distally, a cuneiform process which bears against a special chitinous plate of the trochanter. The cuticle over all segments bears long, stiff, straight or slightly curved hairs, their insertions surrounded by a low rounded ridge. They are most numerous on the distal segments and scarce but constant on the proximal ones. Spurs are constant on the three distal segments, on the other three variable.

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* An ovigerous female 0.75 × 0.40 mm. is used for all measurements unless specially noted.

As a rule there are none on the coxae or trochanter; if present at all it is generally the first two pairs of legs which bear them.

Each leg has a special terminus. The first pair has two arched, subparallel, fairly heavy dorsal claws. Their extremities overhang or touch a single, median, compound-curved, ventral projection with a sharp point, which has the character of neither claw nor spine, appearing more like a chitinous, elongated, pointed tongue. This leg has no caroncle, the base of the claws being set directly into the substance of the tarsus.

The second pair is terminated by a short, broad caroncle measuring about twice as long as broad. It is pyriform, the handle inserted into the tarsus, the ventral and lateral distal parts open to permit protrusion of the claws, the whole now coming to resemble a hood with the opening directed ventrally. It is delicately membranous distally, and heavier proximally. Two strong claws are attached to its dorsum internally. These are parallel at their origins deep in the caroncle, but at their middles become strongly bent laterally, their tips thus coming to diverge and often to project laterally beyond the margin of the caroncle. The details in the depths of the caroncle (the handle) are uncertain. It appears that a median ventral, blunt, chitinous tooth extends from it parallel to the ventral caroncular wall and perhaps continuous with it. It may be straight or lightly curved. The margin of the proximal border of the opening shows a short, pointed, median projection.

The third pair of legs is terminated by a double hooked caroncle precisely like that of the second pair.

The fourth pair also has hooked caroncles built on the same general plan as the preceding, but they are much more slender, measuring about three times as long as broad. Its hooks, too, are much more delicate, more gracefully curved and do not, in the specimens studied, extend beyond the cavity. They are supplemented by a smaller, straighter pair deep in the caroncle, which is not always visible, probably from retraction. The median tongue or tooth is again seen here, but is much smaller, and, too, the median, marginal peak is seen at the proximal border of the caroncular opening.

The cuticle appears for the most part to be soft. It has a pebbled appearance, the elevations so low, far apart and of such irregular size (but always small) that its roughness is not at first sight apparent. In special locations it has the appearance mentioned when describing the hypostome, namely, like a very fine morocco leather. Here the elevations are very small, of uniform size, closely placed and refractile.

One such special area has already been described over the hypostome. A second lies ventrally, suggesting a sternal plate. It is median and extends from the interval between the first pair of legs to a line between the middle of the third pair. It is about three times as long as broad, subelliptical, with both ends flattened. It is not quite so sharply marked off from the surrounding integument as a plate should be. Just within its lateral margins lie six hairs. Two are directly at the anterior margin. The second pair is a little farther apart and between the second and third coxae. The third pair is separated a distance intermediate between the first and second and lies well anterior to the posterior margin of the area, that is, about opposite the middles of the third coxae. All hairs are directed posteriorly.

A third special area lies dorsally, again resembles a plate, is by far more extensive than the ventral and well marked off from the rest of the integument. It extends from a point immediately behind the rostrum to one a short distance behind the fourth coxae. It is broadly ellipsoidal except that the posterior end is roundly pointed. In its widest part it occupies the middle two fourths of the dorsum. It bears five pairs of hairs. The first pair is at the anterior margin. The second is closer behind and much closer together. The third is close behind the second, but now, again, at the lateral margins, and is the farthest apart of any of the five pairs. This brings it on a line with the posterior border of the second coxae. The interval between the third and fourth pair is about the same as that between the first and third. The fourth lies about the same distance below the fourth as that between the third and fourth pairs. These last two are very close together, being the closest of all the pairs. All of the hairs lie in the anterior two thirds of the area, the narrower posterior third being quite naked. This shield bears many small groups of pits commonly ascribed to the traction of subjacent muscular attachments. These groups are on the whole of linear arrangement, paralleling the scutal border (see plate).

The fourth special area lies around the anus. This orifice is terminal and round. In some specimens it is everted and projects beyond the general body contour. This is doubtless a pressure artefact. The special perianal area is subelliptical, with its longer dimension placed longitudinally. Three equidistant hairs lie at its margins, two lateral ventral and one median dorsal. They arch over the anal orifice. No lateral thorns are seen, although in one specimen the fracture and eversion of the anal margins by pressure gave this appearance.

In addition to the hairs which have been mentioned in connection with special areas, a dorsal pair is occasionally found at the level of the broadest part of the body posteriorly and far apart, lying well lateral to the black lines produced by the intestines. A ventral pair is also at times discoverable posterior to the plane of greatest body width. These last two pairs are not constant. Those of the three special areas are constant. All corporeal hairs are inserted in a special ring similar to the ones mentioned in connection with the hairs on the legs, and all are directed posteriorly.

There is but one pair of stigmal plates. They lie between and slightly dorsal to the third and fourth coxae and are about three times as long as broad, the narrower end directed cephalodorsad, the broader end containing the orifice. They show two or three faint curved transverse lines in imitation of segmentation.

The vulvar orifice lies ventrally in the middle of the transverse bridge joining the fourth coxae. It is longitudinal, fissural, short, and flanked by narrow, linear, chitinous plates. It appears to be continuous above with the posterior angle of a laterally elongated triangular opening whose other two angles extend far laterally along the chitinous bridge.

The intestines are indicated by two deep, black, tortuous lines extending longitudinally close to cuticle dorsally.

THE MALE

The solitary male discovered is adjudged such from its slenderer proportions (it measures 0.55 × 0.25 mm.), from the presence of a special anterior ventral orifice, and the lack of the vulvar orifice. In most other respects it is identical in external appearance with the female. All legs have the two dorsal hooks and one ventral piece, there is no caroncle on the first, short broad ones on the two middle ones and a longer, slenderer one on the fourth. The chelicerae in this specimen are, by chance, far extended. At most only the tips of the fingers happened to project in the case of the females. As shown in this male, each is projected from a sheath, extending a short distance beyond the hypostome. Each chelicer has a sharply pointed, lateral, longer, and median shorter, finger, both springing from a common base. The lateral one bends mesially and anteriorly, describing a compound curve. The median one curves upward.

The genital orifice of the male appears close behind the hypostome as a small circular aperture. From it a tube leads posteriorly for some distance directly under the ventral cuticle in a shelving manner, so that to superficial inspection it appears like a median longitudinal furrow.

THE LARVA

A larval form was found close to a ruptured female within which no ovum could be found, from which it is surmised that it escaped from the latter during technical manipulation. The larva measures 0.550 mm. × 0.280 mm., is oval and has six legs, folded ventrally and with long hairs extending, tuft-like, from the distal segments. The anal plate is clearly marked and provided with three hairs.

ZOOLOGICAL POSITION

The writer places this parasite in the genus Pneumonyssus only tentatively and with much unwillingness. In several respects it does not agree with the generic and, furthermore, the superfamily diagnosis. In the former there should be no shields, in the latter no hypostomal armature. Following Banks' key, however, there is no alternative. It is felt that the time for a rearrangement of these endoparasitic Acarians is at hand, and in the expectation that this will be done in the near future it is deemed inadvisable to attempt to announce a new genus for this one species. It should be pointed out at this time, however, that this is the first time that a male Pneumonyssus has been described, and that the position of its sexual orifice places it close to, if not in, the Gamasidae. Indeed Banks has already hinted, in a personal communication, that the genus Pneumonyssus may belong more properly to the Gamasidae than to the Dermanyssidae, on the basis of certain features noted in the nymph of *P. simicola.*

As far as known to the writer, this is the fifth species of arachnoid described from the air passages of a monkey.

Pneumonyssus simicola was found by Banks (1904) in the lungs of a Javanese monkey (*Cyanocephalus* sp. ?) dying of opium poisoning in Java.

Pneumonyssus duttoni was found by Newstead and Todd (1906) in the trachea and bronchi of eleven Schmidt's monkeys (*Cercopithecus schmidti*) in the Congo.

Pneumonyssus griffithi was found by Newstead (1906) in the lungs of six rhesus macaques killed in England after exposure to tuberculosis.

Pneumotuber macaci was found by Landois and Hoepke (1914) in the lungs of a *Macacus rhesus* killed in Breslau.

The description of no one of these four species agrees with this parasite or permits its inclusion in that species.

Pneumonyssus simicola has "a broad pulvillus beneath the claws in some specimens, probably females," whereas a pulvillus is constant on legs i, ii, and iii in *P. foxi*. *P. simicola* has four small bristles on dorsum, *P. foxi* has ten. With *P. simicola* bristles are not present on the coxae. On *P. foxi* they are commonly present. *P. simicola* has no dorsal plate as has *P. foxi*.

P. duttoni is at once excluded by the presence of a transverse body division, two pairs of stigmal plates and its very elongate form. It has a dorsal shield.

P. griffithi has stiliform mandibles; those of *P. foxi* are chelate. The dorsal shields of the former has six hairs, those of *P. foxi* ten. The arrangement of the groups of pores (pits) here is different, too.

Pneumotuber macaci has no shields, only one claw on dorsum of tarsi i, ii, and iii and a pulvillus on tarsus iv only. There are four dorsal hairs as against ten for *P. foxi*.

Finally, and of most importance, with none of the above species is a ventral plate or the special features of the hypostome mentioned. It is true that these are easily overlooked and may have been present in the other species, but until this is shown the parasite here described must remain a new species, though much needed future rearrangement is likely to place it in a different genus or family.

The technical description of the new species follows:

Class, Arachnoidea; order, Acarina; superfamily, Gamasoidea; diagnosis (Banks): Hypostome small, without teeth; venter without furrows; body often with coriaceous shields; posterior border never crenulate; no eyes. Family, Dermanyssidae; diagnosis (Banks): Parasitic on vertebrates; mandibles fitted for piercing; body sometimes constricted. Genus, Pneumonyssus; diagnosis: * A Dermanyssid; stigmal plate a little more than twice as long as broad, situated above and between the coxae of the third and fourth pairs of legs. Body without apparent shields; mouth parts retracted in the head, the palpi very short, scarcely visible; the mandibles have apparently both fingers very slender, elongate and pointed, probably used for pricking the tissues. The legs are stout and short, subequal in length, none as long as width of body, each terminated in two subequal claws. Body nearly twice as long as broad, in the male more slender. Legs with stiff bristles, but body nearly destitute of hairs.

Type species, *P. simicola* Banks.

P. foxi † n. sp.; diagnosis: Adult females, yellowish white, opaque, in width a little more than half the body length. Dorsal shield with ten hairs and pitted areas, ventral with six hairs. Anal plate present with three hairs. All tarsi furnished with two dorsal claws, all except leg i with caroncle in addition; all articles hirsute and most also spinulose. Both tarsi and femora subdivided.

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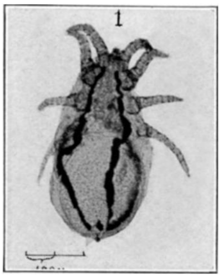
* Kindly furnished, together with other information, in a personal communication by Dr. Nathan Banks.

† Dedicated to Dr. Herbert Fox, who performed the autopsy upon the animal, recognized the parasitic nature of the lesions and submitted all the material to the writer for identification.

PLATE 1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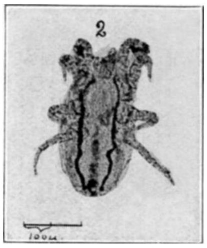
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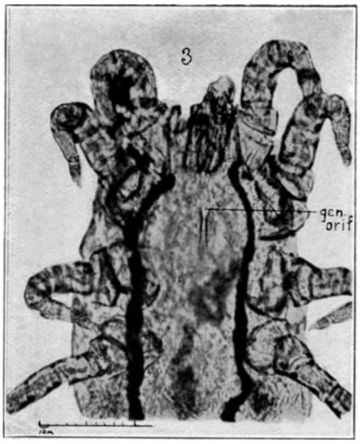
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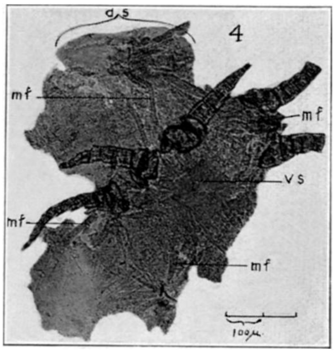
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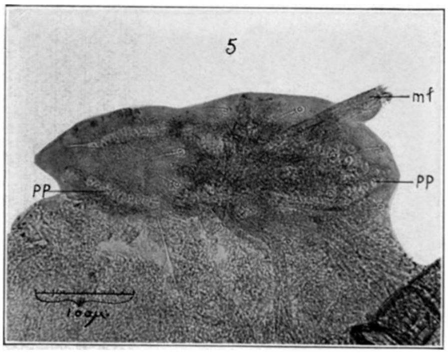
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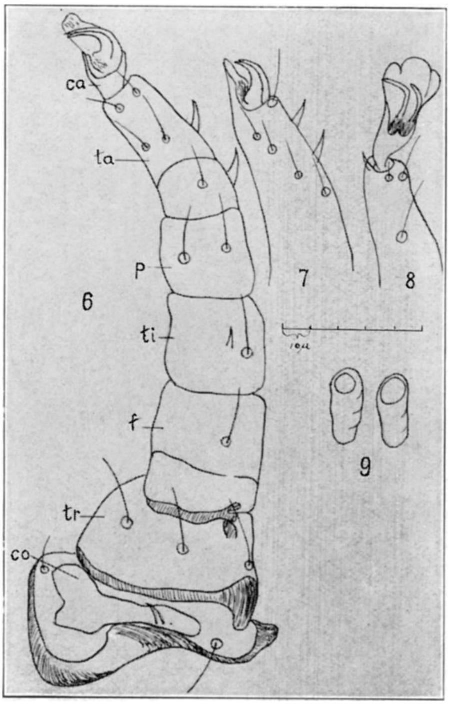
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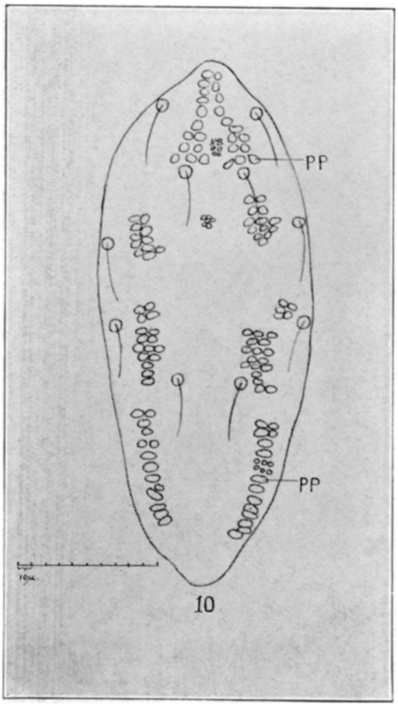
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Palpi of three segments, all short, the terminal one capped by a short bristle. Mandibles chelate in both sexes. One pair of stigmal plates between and dorsal to coxae iii and iv. Hypostome bears a median longitudinal row of 9 to 13 teeth, carries ten hairs anterolaterally and four anterior marginal papillae. Vulva short, median and fissural at level of coxae iv. Adult males measure a little less than half as wide as long. Sexual orifice circular and close behind capitulum. Larva hexapod, oval, 0.55 × 0.28 mm., bears anal plate. Length 0.875 mm., breadh 0.478 mm.

Habitat, lungs of monkey (*Macacus rhesus*).

Autopsy number P. Z. G. 3156.

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EXPLANATION OF PLATE

Fig. 1.—Ovigerous female viewed ventrally. Magnification about 66 times.

Fig. 2.—Adult (?) male viewed ventrally. Magnification about 66 times.

Fig. 3.—Same as Figure 2 but more highly magnified. Shows mouth parts and ventral shield, the latter with genital orifice and six hairs. Magnification about 240 times.

Fig. 4.—Teased adult female: *ds,* dorsal shield; *vs,* ventral shield; *mf,* muscle fasciculi. Magnification about 100 times.

Fig. 5.—Dorsal shield from Figure 4 more highly magnified; *pp,* pits; *mf,* muscle fasciculi. Magnification about 260 times.

Fig. 6.—Leg ii and iii: *ca,* caroncle; *ta,* tarsus; *p,* patella; *ti,* tibia; *f,* femur; *tr,* trochanter; *co,* coxa.

Fig. 7.—Extremity of Leg i.

Fig. 8.—Extremity of Leg iv.

Fig. 9.—Stigmal plates.

Fig. 10.—Dorsal shield. Compare with Figure 5.